RFID-enabled Systems to Enhance Quality of Patient Care in Health Sector

Belal Chowdhury[#1], Clare D'Souza[#2], Nasreen Sultana[#3]

[1, 2]Department of Management, La Trobe University, Melbourne, Australia

[3]Emergency Department, Frankston Hospital, Melbourne, Australia

[#1]M.Chowdhury@latrobe.edu.au

[#2]C.D'Souza@latrobe.edu.au

[#3]nsultana@psolution.com.au

Abstract-**The objective of this research is to review the underlying principles based on quality of care in the health sector. Major components of quality of care include patient safety, effectiveness, and efficiency, which are some of the measures considered. The research demonstrates the use of emerging Radio Frequency Identification (RFID) technology to reduce health care costs. It also facilitates the automating and streamlining of healthcare management process (e.g., identify and locate patient and equipment) in health facilities (such as hospitals, home health monitoring, physician's offices, elderly care facilities, fitness centres and health research studies). Based on the above analysis, the research outlines the design and application of real-time RFID-enabled Health Information System (HIS) applications.**

Keywords-Quality of Care; Patient Safety; Health Performance; RFID and HIS

I. INTRODUCTION

Quality of care has always been a top priority in the medical field and is considered by IOM (Institute of Medicine) as a key determinant of organization's competitiveness and long-term profitability for both the service and manufacturing sectors. A simple definition of Quality of healthcare can be the art of doing the right thing in the right way at the right time for the right person and having the best possible outcome [1]. The literature has considered a more formal definition of quality of care, which can be stated as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge" [2], [3]. These viewpoints suggest that quality of care should be designed to produce outcomes that meet patients' requirements and expectations. Traditionally, research on quality measurement and improvement has focused mainly on other services such as manufacturing or aviation industries. However, given that there have been serious problems associated in the healthcare industry; the focus has shifted more recently measuring quality within the healthcare sector. The rationale behind improving quality is numerous, especially in the light of today's competitive environment, whereby healthcare providers (e.g., hospitals) increasingly realize the need for high service quality as a means to improve their competitive position. In the past, a multi-country evaluation reported that very few countries had been able to document improvements in healthcare quality or in public perceptions about the quality of care [4]. The term quality is coined in different ways by various disciplines. Within the fulcrum of the service industry, Gronroos (2001) indicates that the 'technical' and 'functional' qualities are the two main elements of quality. The technical quality (clinical performance) refers to relatively quantifiable features of a service such as waiting time in the emergency situation in hospitals, service reliability which can be easily measured by the patient and the service provider (i.e., hospitals). On the other hand, the functional quality indicates how technical quality is delivered to patients and how environmental factors (i.e., context-aware) influence the patients [5].

On the global front, due to an ageing and growing population, the demand for health resources, quality standards, efficiency (value for money), acceptability (fair access and ethical operation) and equity (fair payment, fair access to services and equity of outcomes) are needed to promote a better healthcare system. Majority of the Latin American and Caribbean countries reformed the health care sector in the 1990s, the United States during 1989-91, followed by New Zealand reforms in the early 1990s. The major aim of these health reforms was to increase efficiency, improve quality of care from a technical standpoint and user's perspective, expand coverage, and equity between groups [6], [7]. A research undertaken in 2000 on multi-country evaluation reported that very few countries had been able to document improvements in healthcare quality or in public perceptions about quality of care [4]. It is proposed that in the presence of broad-scale health sector reforms that emphasizes on a strong force for change, quality assurance programs can assist with the point of service delivery, allowing healthcare managers and providers to navigate through the system to maximize health outcomes for the communities they serve [8].

Thus the objective of the research is to review the underlying principles based on quality of care in the health care sector. The research will consider quality of patient care which is interpreted across a number of important dimensions that include patient safety, effectiveness, and efficiency [9], [10]. These dimensions are discussed below.

A. Patient Safety:

Patient safety is of key significance and a main determinant of the quality of healthcare services. Patient safety is critical to the sustenance modern healthcare systems. Safety is identified as an issue related to the unintended outcomes (i.e., medical errors, lack of communications between health professionals, etc.) of hospital care, and quality is considered as intended outcomes of care. It measures the overall health status of an organization and the working environment of its staff. Patient safety issues in healthcare were first raised and documented by the Institute of Medicine (IOM), in their 1999 report, "To Err is Human: Building a Safer Health System". It is estimated that 44,000–98,000 patients die each year in the United States as a result of medical errors (more than from breast cancer, AIDS or motor vehicle accidents), which cost

the U.S. $17-29 billion a year [11]. Recently, the NHHRC (2009) report identified patient safety as one of the most important healthcare threats in Western countries such as Australia today [12]. Thus patient safety is the crux of quality of patient care.

B. Effectiveness:

Effectiveness is a key health performance component, which is the degree to which an intervention achieves the objectives set, given the correct provision of evidence-based healthcare services to all who could benefit, but not to those who would not benefit [13], [14]. Communication failure is one of the major causes of preventable harm to patients in healthcare facilities [15].

C. Efficiency:

Efficiency is an important performance requirement. Sir Peter Gershon identifies efficiency as **"**making the best use of the resources available for the provision of public services." There are many ways by which efficiency can be achieved, however, the literature suggests that efficiencies can be achieved [16] by

- reducing the numbers of inputs (e.g. people or assets), whilst maintaining the same level of service provision; or

- lowering prices for the resources needed to provide public services; or

- additional outputs, such as enhancing quality or quantity of service, for the same level of inputs; or improving ratios of output per unit cost of input.

Within the healthcare context (i.e., changes in the patterns of demand and supply), accounting for a sizeable proportion of national expenditures, and the coordination of care has become a key policy response to improve efficiency and effectiveness of health care delivery. Efficiency reduces medical errors, so it brings about cost efficiency and cost effectiveness. It is also suggested that this leads to higher workforce productivity – e.g. through reduced sick leave [17] – overall economic efficiency will also improve.

Efficiency justifies a system's ability to function at lower costs without diminishing attainable and desirable results [18]. Thus the efficiency as a quality measure in the health care sector denotes not only cost effectiveness but also value in terms of quality and service. Furthermore, the quality care is determined not only by technological advances in preventing and treating disease but also by health providers' (e.g., hospitals) ability to deliver the benefits of those advances to patients.

Thus it can be seen that there is a constant need for improving quality in services, especially in cases where technology advances. In this paper, we outline the present status in services of health care to gain broader insights and infer a rationale for providing technology advanced services.

II. PRESENT STATUS IN QUALITY OF CARE

There is a demand for quality in technology and service by individuals and organizations as the world becomes technology savvy. Since technology offers computer-based solutions for improving medical care, it resolves the problem to make healthcare organizations more efficient from a service perspective. International Standards Organization (ISO) 9004 has highlighted the fact that a good quality of service can lead to cost reduction, improved productivity, efficiency and customer satisfaction [18], making quality services a prerequisite in any industry.

The main players in today's healthcare industry are consumers, providers, payers (government) and health regulators. Consumers are the one who uses healthcare services. Anyone who is involved in any way in delivering healthcare to consumers is a provider, which includes hospitals, home health monitoring, physician's offices, elderly care facilities, fitness centres, and others. Healthcare is subjected to a plethora of federal and state government regulations. With respect to technology, this research has expanded the services triangle to a pyramid as shown in Fig. 1.

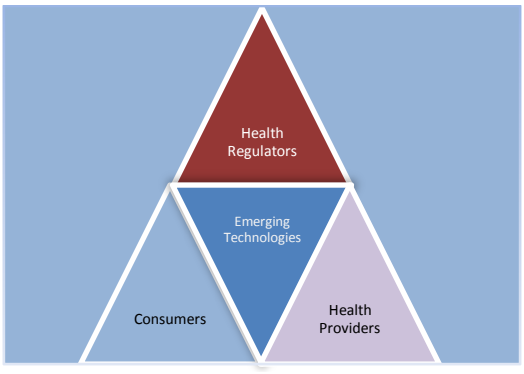

Fig. 1 The service triangle technology [19] (revised)

The pyramid indicates that interactive services can be the outcome of collaboration between all stakeholders (i.e., payers and health providers) and emerging technologies interacting at a given point in time. It is the regulators' responsibility to provide the technology and the service for the providers to ensure service quality for their patients in the healthcare system. Government support appears critical for the smooth operation of such a service.

Quality of service provision in healthcare involved with different stakeholders might place different emphases on different aspects of quality. Clinicians typically emphasize clinical quality, whether the service is provided safely and achieved expected outcomes of care. Whereas consumers, on the other hand determine the quality of services based on accurate patient identification, timeliness of access and cultural appropriateness [7]. Health care providers such as hospitals are dealing with greater rank diseases. Their cost, quality and delivery haven't essentially improved significantly, despite the differences with the other industries seem to have increased [20].

Healthcare system will be facing a number of significant challenges to quality of patient care worldwide over the next decade. For instance, ageing and growing population is not the only traditionally lamented issue that drives health care cost out of control. Instead, the key problems facing the healthcare system are internal ones: ensuring patient safety and quality, choices about roles of health professionals (e.g., doctors and nurses), lack of communication between health professionals, addressing the inequalities on health outcomes, and improving efficiency. Concerns about health system viability, efficiency, and effectiveness will continue to be addressed in the 21st century [7].

The length of treatment and care needed for patients with chronic illness and the requirement of medical attention for mundane checkups take away health professionals (nurses, doctors, consultant or GP) valuable time and this again adds

to the problem of considerable waiting time in the healthcare system. In order to tide over this situation a remote monitoring is suggested to provide continuous disease management support systems so that aged people and patients with chronic illness can fend for themselves [21]. In the health care context, we might consider the Internet to deliver some services in remote areas. So far, the Internet makes an entire range of new technologies available to health providers (e.g., hospitals) to facilitate communications and build relationships. The application of the above principles can be facilitated by the use of emerging technologies such as Radio Frequency Identification (RFID). RFID is one of the wireless technologies that elegantly provides a solution, and assists healthcare facilities by detecting and tracking a patient, equipments/assets and their location in real-time. The benefits of having RFID-based healthcare system are enormous, for instance to improve health care quality, prevent medical/hospital errors, reduce health care costs, increase administrative efficiencies, decrease paperwork, and expand access to affordable care, an issue that is of concern to governments worldwide [22]. Today's advanced technology is capable of uniting smart RFID tags and data processing into a single integrated system [23].

In this paper, we integrate RFID technology with a multi-layer architecture for HIS via wireless network to improve quality of health service delivery systems. This paper is structured as follows: Section III outlines the RFID model used for developing patient identification, detection and monitoring system. Section IV illustrates the application of patient monitoring systems architecture using a RFID-enable HIS. Section V concludes the paper.

III. RFID MODEL IN HEALTHCARE SYSTEM

The RFID model facilitates the structure that can seamlessly integrate the captured data at various levels in the healthcare business process with the backend databases, backend applications and decision support system. The main components of RFID-based HIS are shown in Fig. 2. It mainly consists of a unique patient tag (i.e., wristband) which can be issued to every patient at registration, a reader and health care provider IT systems (i.e., Real-Time RFID-Based HIS). Each unique patient tag can be passive, semi-passive or active. Passive patient tags can be used for both reading/writing capabilities by the reader and do not need internal power (i.e., battery). They get energized by the reader through radio waves and have a read range from 10mm to almost 10 meters. Passive tags are cheap, ranging from $0.25c to $0.40c each and life expectancy is unlimited. We suggest the use of passive patient tags (13.56 MHz ISO 15693 tags) with the read range of one meter, and iPad, PDA/Next G Smart Phone RFID readers for the real-time Healthcare Management System (i.e., HIS) application.

The passive patient tag antenna picks up radio-waves or electromagnetic energy beamed at it from an RFID reader device and enables the chip to transmit patient's unique ID and other information to the reader device, allowing the patient to be remotely identified. The reader converts the radio waves reflected back from the patient tag (i.e., wristband) into digital information, and then passes it onto HIS system for processing.

Patient's basic information (e.g., patient id, name, age, blood group, drug allergies, drugs that the patient is on today and so on) is stored in the back-end server (local server and/or central database) via wireless networks for processing data. In addition to monitoring patients, the system can also track equipments or assets that include wheelchairs, beds, staff member and surgical equipments in real-time. The patient database can also be linked through Internet into local server or central databases for retrieving patient's medical information (e.g., past history).

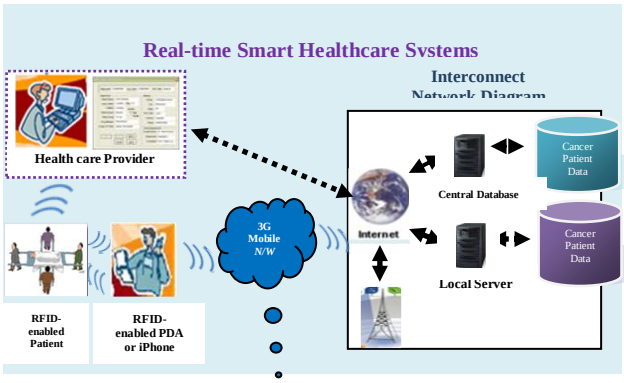

Fig. 2 Main components of RFID enabled healthcare system

IV. RFID-ENABLED HIS APPLICATION

As the healthcare industry faces data integration issues, the RFID device management is a challenge while deploying RFID devices in their health provider's system. Multi-layer RFID architecture establishes an infrastructure to address such a challenge, to automate and simplify the functionality for building RFID-based solutions in the healthcare system. These integration layers (i.e., five layers) are namely, physical device layer, middleware layer, IT infrastructure management layer, data layer and graphical user interface layers.

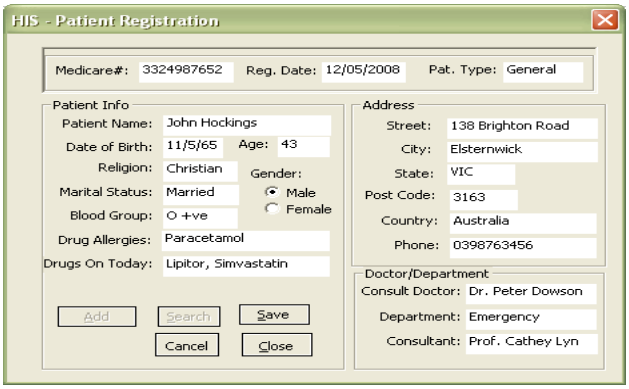

Fig. 3 (a) RFID-enabled wristband (patient tag) assignment at patient registration

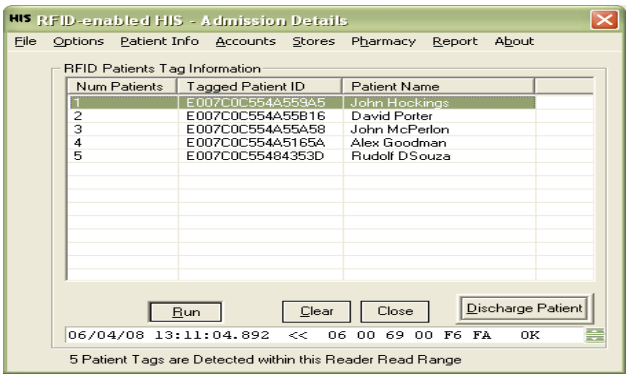

Fig. 3 (b) Patient monitoring at healthcare facilities (e.g. hospitals)

Fig. 3 (a), 3 (b) and 3 (c) show the RFID-enabled HIS application, which can be integrated with the healthcare providers IT System for capturing patients, medical equipment, or asset data and their location automatically and wirelessly.

The system was developed in Microsoft Visual Studio.net 2003 environment using Visual C++ (MFC). The RFID-based HIS application issues a unique tag ID to every patient with a wristband at registration/admission in hospitals is shown in Fig. 3 (a). The RFID then uses the tag ID as a key to information and perhaps other information (e.g. name, DOB, drug allergies, blood group, etc.) stored in the health providers back-end databases (i.e., SQL server or central database).

The wristband is used to identify and detect patients all the way from observation, investigation, and treatment to discharge while in hospital. For example, a RFID patient tag only contains a unique tag ID, which HIS application uses to retrieve a patient record stored in the database. When a patient appears with a wristband within a reader (i.e., placed in hospital wards, clinical labs, pharmacies, radiology departments, and so on) read range, the application reads and lists the tagged patient IDs, names and displays the patient admission information automatically on a selection of a particular patient as shown in Fig. 3 (b) and 3 (c). The RFID patient tag (wristband) can be removed from the patient on discharge from the hospital. The available wristband from such a patient can be reused.

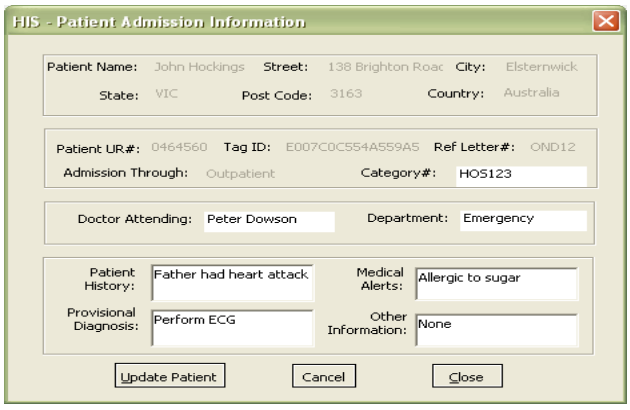

Fig. 3 (c) Patient management and treatment at hospitals

V. CONCLUSIONS AND FUTURE WORK

The paper demonstrates how to apply RFID techniques to the healthcare system. We have shown how the RFID-based system architecture and HIS application can improve quality of patient care in health sector. It forms the basis of using HIS by which health care providers (e.g., hospitals) can track patients' identification fast and accurately, improve patient's safety, prevent/reduce medical errors, increase efficiency and productivity, and save cost via wireless network. Given this opportunity the HIS may be in a better position to assist hospitals to build a better, more collaborative environment between different departments, such as the wards, medication, examination, and payment.

For the health care provider the implications are substantial. An efficient and effective RFID process can provide vast benefits to patients. For instance, maintaining his or her own personal records would help to eliminate duplication and give a historical account of the patient's well being. More in-depth information about a particular patient enhances the efficiency and effectiveness of health self-management. It is our expectation that future experimental research will be able to provide a more in-depth analysis for substantiating the above model, which will help assisting with public policy initiatives.

REFERENCES

[1] Runciman, W. B (2006), The Safety and Quality Of Health Care: Where Are We Now? Shared meanings: preferred terms and definitions for safety and quality concepts, MJA (The medical journal of Australia) 2006; 184 (10 Suppl): S41-S43

[2] IOM (Institute of Medicine) Crossing the Quality Chasm: A New Health System for the 21st Century. Washington DC: National Academy Press; 2001.

[3] OECD (Organization for Economic Cooperation and Development): Towards High-Performing Health Systems. Paris: OECD; 2004b.

[4] Infante A, de la Mata S, and Lopez-Acuña D. 2000. Health sector reform in Latin America and the Caribbean: Situations and trends. Pan American Journal of Public Health, July-August: 13–19.

[5] Gronroos, C. 2001. The perceived service quality concept – a mistake? Managing Service Quality 11 (3), 150-152.

[6] Menadue, J. (2003), Healthcare reform: possible ways forward, The Medical Journal of Australia (MJA), 2003; 179 (7): 367-369

[7] Duckett, S.J. (2007), The Australian Health Care System. (Third edition) Melbourne, Oxford University Press.

[8] QAP-PAHO (Quality Assurance Project and the Pan American Health Organization), (2004), Maximizing Quality of Care In Health Sector Reform: The Role of Quality Assurance Strategies, University Research Co., LLC 7200 Wisconsin Avenue, Suite 600 Bethesda, MD 20814 USA.

[9] Kozmenko V, Paige J, Chauvin S, Initial implementation of mixed reality simulation targeting teamwork and patient safety. Studies in Health Technology & Informatics 132:216-21, 2008.

[10] IOM (Institute of Medicine), (1999), To Err is Human: Building a Safer Health System. Washington, DC: National Academy Press.

[11] Kohn LT, Corrigan JM, Donaldson MS, editors (2000), To err is human: building a safer health system, A report of the Committee on Quality of Health Care in America, Institute of Medicine. Washington, DC: National Academy Press; 2000.

[12] NHHRC (The National Health and Hospitals Reform Commission). (2009), Beyond the blame game: accountability and performance benchmarks for the next Australian healthcare agreements, Canberra.

[13] Arah OA, Klazinga NS, Delnoij DMJ, ten Asbroek AHA, Custers T: Conceptual frameworks for health systems performance: a quest for effectiveness, quality and improvement. International Journal for Quality in Health Care 2003, 15: 377-398.

[14] WHO (World Health Organization): The World Health Report 2000. Health Systems: Improving Performance. Geneva: WHO; 2000.

[15] Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. Acad Med. 2004;79:186–94.

[16] Gershon, S. P. (2004), Releasing Resources to the Front Line - Independent Review of Public Sector Efficiency, July 2004, http://www.hm-treasury.gov.uk/media/C/A/efficiency_review120704.pdf accessed on 07 August 2008.

[17] Donabedian A. (2003), An Introduction to Quality Assurance in Health Care. Oxford: Oxford University Press; 2003.

[18] McColl, R., Callaghan, B. and Palmer, A. (1998), Services Marketing: A Managerial Perspective, McGraw-Hill Book Company Australia, Roseville: NSW, 156

[19] Parasuraman, A (1996), Understanding and leveraging the role of the customer service in external, interactive and internal marketing , Frontiers in Services Conference, Nashville, TN cited in Zeithaml, V and Bitner, M, (2000), McGraw Hill Higher Education, Services Marketing: Integrating customer focus across the firm, 2nd edn. New York: USA

[20] Correa, F. A., Gil, M.J., and Redín, L.B. (2005), "Benefits of Connecting RFID and Lean Principles in Health Care", Working Paper 05-4, Business Economics Series 10.

[21] Johnstone, D. (2007), The challenge of making healthcare and socialcare information systems interoperable, The British Journal of Healthcare Computing and Information Management, March 2007, Volume 24 Number 2, 16–17.

[22] Banks, J., Hanny D., Pachano, M. A., and Thompson L. G. (2007), RFID Applied, John Wiley & Sonsm, Inc., Hoboken, New Jersey, p311-318.

[23] Drucker, P.F. "The essential Drucker: selections from the management works of Peter F. Drucker", New York: HarperBusiness, 2001.